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Allen County Soil & Water Conservation District, Ft. Wayne, Ind.

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ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY

Black Creek Project
Allen County, Indiana

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Prepared for

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16. Abstract
The Black Creek sediment control study, an Environmental Protection Agency-funded project to determine the environmental impact of land use on water quality. The project is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie and is described in this report.

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The Black Creek sediment control study, an Environmental Protection Agency-funded project to determine the environmental impact of land use on water quality is finishing its second full year of activities. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie.

The Black Creek project was designed and developed by a consortium of the Environmental Protection Agency, the Soil Conservation Service of the United States Department of Agriculture, Purdue University, and the Allen County District. It is a response to allegations, first brought to the attention of Allen County residents at a Conference on the future of the Maumee River sponsored by Rep. J. Edward Roush in January of 1972.

At the conference, sediments and related pollutants were named as major contributors to the degradation of water quality in Lake Erie. It was further suggested that agricultural operations significantly increased the amount of sediment and sediment related pollutants.

The Black Creek Sediment Study, funded by a grant of nearly $2 million, is an attempt to discover the role that agricultural operations play in the pollution of the Maumee River and how that role can be diminished through the application of significant land treatment practices.

The project represents a multi-agency, multi-discipline approach to the total problem of non-point source pollution. It involves demonstration, through a program of accelerated land treatment under the direction of the Soil Conservation Service, applied research by Purdue University, administration by the Allen County Soil and Water Conservation District, and cooperation from a variety of state, federal, and local agencies.

The problem of non-point source pollution is becoming more and more important in the nation's overall effort to clean up the degraded streams and lakes. As major point sources of pollution such as industries and municipalities are brought under control and begin to contribute less and less of the total pollutant load, the necessity of controlling pollution which originates from small, hard to identify sources becomes more and more critical.

Our understanding of the mechanisms by which pollutants from diverse small sources is carried into the nation's waterways to become — in the aggregate — a large problem is not so advanced as is our understanding of the monitoring and control of point-source pollution. The Black Creek project is intended to provide significant data on which future decisions about efforts to control this type of pollution — if it indeed can be controlled at a cost that all citizens are willing to bear — can be based.

After two full years of operation, some significant results have been obtained. Not the least significant of the activities has involved the ability of the project agencies and other agencies and individuals to work together toward a common goal.

Particularly important to the successful operation of the project over two years has been the supervision and encouragement provided by the Environmental Protection Agency acting through Ralph Christensen, Administrator of Special Great Lakes Programs under which funding for the project was obtained and Carl Wilson, project officer.

Not directly under the project umbrella but furnishing great assistance and encouragement have been persons such as Allen County Cooperative Extension Agent Ernest Lesiuk, Indiana State Forester Larry Lichtsinn, and Wildlife Biologist George Kennedy. Mr. Lichtsinn and Mr. Kennedy are

representatives of the Department of Natural Resources of the State of Indiana. Significant help and cooperation has also be afforded by local agencies such as the office of County Surveyor William Sweet, the Allen County Data Processing Department, the Allen County Plan Commission, and the Allen County Commissioners and Allen County Council.

Fourth District Congressman J. Edward Roush, whose conference inspired local individuals to undertake a project such as this, has continued to offer advice, support and assistance to the project. It has been gratifying during the past year to be able to exchange data and ideas with agencies such as the International Joint Commission on Great Lakes Water Quality and the Great Lakes Basin Commission.

PREVIOUS REPORTS

The basic plan for the Black Creek Study is described in a work plan, *Environmental Impact of Land Use on Water Quality*, (EPA G005103) published in May of 1973. Standards by which this work was to be carried out were described in great detail in *Operations Manual Black Creek Study, Allen County, Indiana* (EPA Document 905-74-002). Progress during the first year of operation, June, 1973, to July, 1974, is reported in the first annual report on the Black Creek project. Research and demonstration efforts in the first year of the project centered on:

(1) A sociological survey of the Black Creek area
(2) Conservation planning and application
(3) Water Quality monitoring
(4) Water sample analysis
(5) Rainfall simulator studies
(6) Fish population studies
(7) Stream Bank studies
(8) Tillage Demonstration plots
(9) Modeling of the basin

Much of this work furnished a base on which activities which can be reported at the end of the second year were based.

During the second year of the project, many accomplishments were reported; however, certain problems have developed. It has become clear that technical assistance and

Land Treatment

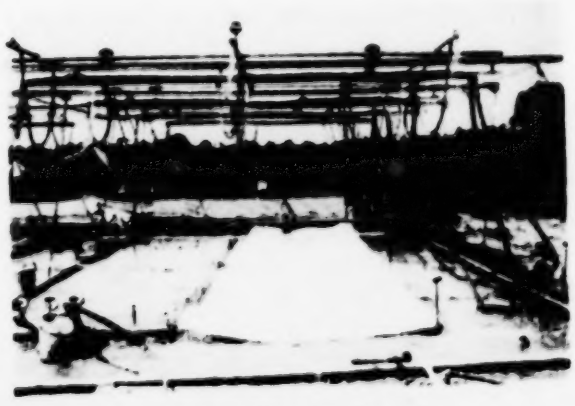
Land Treatment

financial incentives are not sufficient to convince every farmer or landowner to install needed conservation practices. This opens the question for future consideration of how land treatment is to be achieved if the research undertaken indicates that, in fact, land treatment can have a major impact on water quality.

Major research and project efforts to date are summarized below:

Simulated Rainfall

Rainfall simulator test storms totaling five inches were applied to treatments on four soils in the Black creek watershed. The four soils were Haskins loam 1.8 percent slope, Nappanee clay loam 0.7 percent slope, Hoytville silty clay 0.8 percent slope and Morley clay loam 4.0 percent slope. Runoff and soil loss measurements were made in late spri g on the following treatments: (1) check (crop residues as left by the harvester), (2) fall disk, (3) fall chisel, and (4) fall plow. These treatments were representative of conditions that occur in late winter and spring after the fields have undergone winter weathering. Results showed amount of residue left on the surface (as a result of type and amount of tillage) to have major effects on soil loss. Residues ranged from a low of 1 percent surface cover on the plowed plots to a high of 78 percent on the check plots. Also, residue remaining on the surface following a corn crop was about three times as great as following a soybean crop. Soil losses from fall disk and check treatments were similar and only 18, 17, 24, and 32 percent, respectively, of those from fall plowing on the Haskins, Nappanee, Hoytville, and Morley soils. Soil losses from fall chiseled land were 53, 58, 37, and 74 percent, respectively, of those from fall plowing on the same four soils.



Rainfall Simulation

Tillage Demonstrations

Tillage Management

Demonstration of conservation tillage techniques was begun in the Black Creek Watershed in 1974. The main objective of the tillage demonstrations is to increase conservation tillage acreage in the Watershed through acquainting farmer cooperators and their neighbors with techniques and management practices necessary for the success of conservation tillage. The demonstrations included six soil types on four farms.

Tillage systems compared included fall plow conventional, spring plow conventional, fall chisel, shallow tillage (tandem disc), and "no-til" planting. All trials were for corn following corn in 1973. The 1974 growing season was unusual throughout, with excess rain in the spring, a severe summer drouth, and an early September frost. Yield information from 1974 may be of little value in predicting corn response to different tillage methods in more normal seasons.

In this first year of the trials, fall chiseling produced yields equal to or better than mold-

board plowing in all trials except those on poorly drained Nappanee silt loam. Chiseled acreage appears to be increasing in the area and offers all but Amish farmers a soil conserving system adapted for widespread use in basic land preparation. Shallow tillage and "no-til" planting produced more variable corn yields than either plowing or chiseling on the poorly drained soils.

Mulch Studies

The ditch bank-slope-mulch studies were completed in May, 1975. All mulch materials were effective in controlling erosion and in promoting the establishment of a grass cover. The stone mulch was slightly superior for erosion control.

The ditch bank stability studies have shown no significant erosion or accumulation during the first two years of observation. Channel stability studies are being initiated on three locations where evidence of channel scour or soil mechanics tests indicate potential for instability.

From September, 1974, to July, 1975, 480 cubic yards of material have been deposited in the desilting basin. Particle size of the material has yet to be determined. An intense storm on May 20, 1975, undoubtedly accounts for a large part of this volume of deposited material.

The May 20 storm produced nearly four inches of rain in two and one-half hours.

Mulch Studies

Fish Community Dynamics

Analysis indicates that the return frequency of the rainfall is less than 1 in 100 years. The storm produced ditch bank full-flows and general flooding throughout the level lake bed area. All of the installed conservation measures performed well during the subsequent runoff. While considerable erosion did occur, the infrequent nature of the storm must be recognized. It is probably not practical to expect to control all damage from such an intense and frequent event.

Community Dynamics of Fish

Recognition of the significance of seasonal movements into Black Creek from the Maumee River was an early conclusion of field studies. These movements are particularly striking in the spring but continue into the early fall with a different set of species. Bridge construction at Ward Road produced a major blockage and rip-rap, in association with stage-recorder weirs, temporarily blocked several of the tributaries of Black Creek. These two factors resulted in smaller numbers of fish in Black Creek during the spring migration (1975) with a particularly striking decline in larger fish. Fish populations also declined following bank reconstruction. The extent to which these communities did not regenerate due to the reconstruction or due to stream blockages mentioned above is not clear.

The most complex and stable fish community in the Black Creek Basin above Ward

Road is found in a small woodlot on the Wertz Drain. Because of the shading by the trees and the meandering nature of the stream in this area, temperature, oxygen, sediment, and nutrient regimes are more buffered than in channelized areas. This results in fewer algal blooms and a more stable, resident fish fauna. Studies of the robustness of Black Creek fish indicate that species which migrate into Black Creek from the Maumee River are similar to other midwestern populations of the same species. Black Creek residents, on the other hand, are much less robust than other populations, suggesting that the "health" of the fish of Black Creek is below that of more natural streams. All of these factors indicate the importance of both the stream basin and the terrestrial environment in the immediate vicinity in determining the structure of the fish community.

Water Quality Monitoring

Water samples have been obtained on a weekly basis from 14 sites located on the Maumee River and Black Creek and its tributaries. Pump samplers installed at three sampling sites in the lower portion of the watershed enable detailed analysis of storm events and potential loadings of nutrients into the Maumee River. The following parameters are measured in all water samples: suspended solids, total nitrogen, total soluble nitrogen, ammonium-nitrogen, nitrate-nitrogen, total phosphorus, total soluble phosphorus, soluble inorganic phosphorus, total carbon, and total soluble carbon. A comprehensive survey of tile drain effluents was conducted in spring, 1974. The water quality data obtained suggest, in conjunction with other studies, that nutrient concentrations in subsurface flow exceed those found in surface runoff. The influence of agricultural and domestic drainage is readily apparent in the nitrogen and phosphorus analyses of water samples. In general, concentrations of different forms of nitrogen are similar in the Maumee River and the Black Creek area whereas phosphorus concentrations in the Maumee are elevated with respect to the watershed.

Water Quality Monitoring

Water Quality Monitoring

Discharge into Lake Erie

As part of the study effort, historical data using U.S. Geological Survey records of stream flow and sediment transport near the mouth of the Maumee River and U.S. Weather Bureau records were analyzed. Graphs of sediment loads and discharge show high discharge and sediment movement in the winter months, December to March. The time frame for maximum hydrologic events from small catchments, however, does not coincide with that of the basin. The small catchments are more responsive to local, convective-type storms which occur later in the year. Runoff from the small catchments moves eroded soil down slopes,

into intermittent waterways or into streams for subsequent transport by basin-wide storms. Runoff patterns are also influenced by extensive systems of subsurface drains which underlay most of the agricultural lands. Unfortunately, these drains also discharge a relatively small but almost continuous amount of suspended colloidal material. High discharge from the subsurface drains occurs in the winter months following complete thawing of the soil and in spring months following heavy rainfall.

The erosion-sedimentation process in a river basin can in general be divided into upland and in-channel phases. For the purpose of this study, the main channels of the Maumee River Basin are assumed to be in dynamic equilibrium so that the average annual sediment discharge into Lake Erie, except for manmade traps, equals the average annual erosion rate of the entire basin into the main channels. An erosion-sedimentation model based on rigorous theoretical considerations has been proposed for the upland phase. Consolidation of the results from all the small catchments within the basin into a comprehensive basin model will then be possible.

Automatic Pumping Samplers

The automatic pumping samplers (PS 69) were installed at stations 2, 6, and 12 in the Black Creek Watershed and have been operating since February 22, 1975, March 17, 1975, and April 4, 1975, respectively. The stations are located in the lower section of the watershed to allow the sampler data to closely describe the water quality constituents movement from the watershed. The physical operation of the samplers has been very satisfactory.

The samplers are energized only while the stage in their respective stream is above the one foot level. While energized the samplers take a water sample every thirty minutes.

Data collected during three storms in late February and mid March has been analyzed. This preliminary data indicates that in all cases the nutrients and suspended solids transported by a stream increases with increasing flow. More importantly the nutrients and suspended solids concentrations also increase with increased flow with the exception of ammonia and nitrate whose concentrations showed very little variation during a storm event.

Sociological Studies

Sociological Studies

Attitudes of both Amish and non-Amish landowners were compared in an attempt to better understand how local people perceive pollution control and their willingness to participate in abatement programs. Both groups need to be understood in their cultural context. Second, the leadership structure among the non-Amish landowners was analyzed. Preliminary examination of the types of chemical fertilizers used by both Amish and non-Amish give indication to what landowners are applying to the land. These data will be useful in further understanding the nutrient content observed in water quality studies.

There are mixed feelings concerning conservation of soil. Both groups are equally divided among themselves as to the extent of soil problems that exist in the Black Creek. Farmers do not feel they should stand the cost of soil erosion programs alone and expect the federal government to stand between 25 to 50 percent of the cost. Education is considered by landowners to be the most effective tool to get cooperation on protecting water quality. Laws and federal controls

are opposed and less than 15 percent felt financial incentives would be effective.

There are interesting differences between leaders and non-leaders in the non-Amish group. Those individuals selected by their peers as influential in agricultural affairs are more knowledgeable about pollution control and the role government can play in pollution abatement programs. Finally, there are differences in chemical fertilizers applied by Amish and non-Amish. Contrary to popular belief, the Amish use chemical fertilizers. Their types, however, are generally different than those analyses selected by non-Amish.

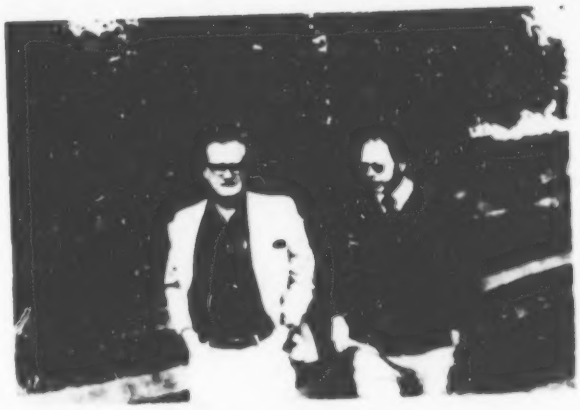
Plans for Next Year

Several changes have been planned for operation of the Black Creek project during the coming year.

The Allen County Soil and Water Conservation District is giving serious consideration to adding an employee of the District whose primary function would be to follow-up on agreements made with landowners to see that the terms of the agreement are in fact carried out.

A change in the scope of the tillage demonstration effort will involve the renting of large tracts (up to 20 acres) and the carrying out of farming operations by a Purdue University employee. This will allow both replication of results and better control of the demonstration effort.

Management



Management

An automatic tile sampler is being installed near the Black Creek Watershed to investigate the influence of tile drainage systems on the total water quality of their respective streams. It is known that in some locations as much as 50 percent of the annual sediment loss is coming through the tile outlets. This indicates the vital need for understanding and describing the influence of subsurface drainage in order to complete a reliable watershed model.

The sampler will monitor a 10 inch diameter tile outlet which drains 63 acres of Hoytville silty loam soil. The entire 63 acres are nearly flat and very uniform in soil type. The uniformity of the field will greatly help in developing and verifying a reliable model for tile systems. Crop cover for the field is a standard corn-soybean rotation.

The area is not in the Black Creek Watershed because a uniform well managed tile system could not be located within the project boundary. The systems in the watershed either lacked a tile line layout record or were put in within the past three years. Even though the tile sampler site is not in the watershed it does well represent the tile drainage systems in the Black Creek Watershed.

The sampler will have the capability of collecting 72-500 ml water samples on a constant volume passed basis. The sampling rate will be approximateiy one sample per thirty minutes at maximum flow and no samples taken at zero flow with a linear re-

sponse to intermediate flows. A flow record will be made continuously and an event mark on the flow record will designate when a sample was taken. The sampler station will have a 350 gpm pump in conjunction with a sump to prevent the tile outlet from being inundated during storm events. During low flows, the outflow will pass directly through the station with no pumping required.

The project will include three new objectives: (1) the development and operational evaluation of an automatic, real-time system for acquisition and analysis of hydrometeorological data, (2) the development of a distributed parameter watershed model to provide real-time hydrologic prediction of stream flows in the Black Creek watershed, and (3) automation of existing procedures for collecting environmental data from the watershed.

The additional electronic transducers required to provide computer compatible signals corresponding to standard meteorological variables have been ordered. Permission has been obtained from the affected landowners to locate these additional instruments in the catchment. The installation of required underground cabling and a direct telephone link between the watershed and the Agricultural Engineering building on the West Lafayette campus is currently underway. The design of special electronics to interface the field instrumentation, both new and existing, to a minicomputer system on the Purdue campus is nearly completed.

The schedule of accomplishments anticipates initial operation of the primary meterological station and the telephone transmission of its data to West Lafayette in late October or early November. Installation of additional field equipment to provide computer control of water sampling will proceed within a month after successful completion of initial testing on the integrity of the data link between the watershed and campus. Expansion of the network of field instrumentation using radio telemetry is planned for the summer of 1976.